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PAYLOAD IVA TRAINING AND SIMULATION

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ABSTRACT

Training activities for the payload are the only Space Shuttle flight courses which are not the responsibility of NASA*. Payload training is conducted by the payload developer. Lockheed, in this role, has implemented a training development methodology, in support of its payloads, which is economical to the program while fulfilling the contractual requirements. The major points of this paper describe Lockheed's training and simulation development approach and contrast them with both the NASA and the Instructional Systems Development approaches, to illustrate how economics are achieved.

* Excluding those NASA payloads developed 'in-house'.

Challenges of Payload Training Development

Payload IVA training programs present some unique challenges to the contractor. These tend to make the development of payload training relatively expensive proposition. The four primary "unique" characteristics and the methods Lockheed is using to meet the challenges they present are discussed below. They include (1) compliance with established training standards, (2) meeting varied needs, (3) maintaining security, and (4) accommodating changes.

Compliance With Established Standards

An initial consideration is that as the contractor, Lockheed, is developing training for a clientele with very regimented procedures, operations languages, and document

formats. Payload training development teams must be familiar with NASA documentation and the customer's preference (Military specifications, Military standards, etc.) to insure development of acceptable training programs. The key to cost reduction is for the contractor to be close to 'on target' with the early iterations of the training plan and the first package of training materials.

Meeting Varied Needs

The Payload training programs are designed to familiarize all of the responsible crew members with Space Shuttle payloads. All of the personnel who must become familiar with the payload's characteristics, payload operations, and the materials equipment and aides associated with those operations will be taught by the contractor. While the training is intended for the Payload Specialist, since he is the primary operator, the courses must be given also to Payload Operations Control Center (POCC) ground crews, NASA ground crews, and the NASA flight crew, to meet their specific needs. Typically, while the Payload Specialist operates the payloads from the aft flight deck, the Mission Specialist is his IVA back-up, the pilot provides EVA support, the commander and pilot position the Orbiter and use the RMS to support payload operations and the ground crews execute commands and monitor crew activities and payload status. The instruction associated with payloads, then must be packaged in several ways to meet the varied needs. The challenge to the contractor, attempting to compete in the payloads market place, is to develop the fewest programs possible for meeting everyone's needs.

Maintaining Security

Another unique characteristic of payloads is that some of them must be built, tested and operated in secrecy. Classified payload training imposes many constraints on the contractor as the training developer, and on all of the personnel who are to be

trained. Payload courses which are classified must handle and control classified materials, provide secure training facilities and secure simulation interfaces. Obviously, classified training is a cost driver, but costs can be controlled through a mature security program. The primary planning factor which is impacted by classified training courses is response time. Because of the requirements for all program participants, written materials and training aids to be controlled, there is a slow-down effect on requirements analysis, course development, and course implementation and revision.

Accommodating Change

A second characteristic of payload training programs, in contrast to the NASA Space Shuttle flight programs, is that the hardware and the operations tend to be uniquely different for each payload. There is very little "generic" training in the payload curriculum. A second challenge, then, is to continue to develop totally new programs, while maintaining quality in the curriculum.

LMSC Approach to Payload Training Challenges

The training development responsibility for each Lockheed payload falls on each specific program office. The Program Training Manager staffs his training group as efficiently as possible. The manager usually calls upon LMSC's Space System Division's Crew Systems organization for providing an experienced Space Shuttle interface team.

The Crew Systems group employs a variety of disciplines, which interface with program engineers at various stages of program development. Figure 1 gives a breakdown of the LMSC Crew Systems group and highlights the relationship to training and simulation for each program. This approach of manning the program

with a Shuttle oriented group, assures that a body of experience will be available to each new program.

The Program Training Manager uses the Crew Systems personnel (who have usually been involved in program proposals) to interpret both NASA and military standards and specifications, to review standard NASA and Ground Crew operating procedures and to assist in or lead the development of specific modules of the training program. The availability of a body of personnel who are experienced in Shuttle Payload development is invaluable in the efficient production of new training programs.

A vital element of new payload training program development is interface planning. Lockheed has established three levels of working groups to insure this interface. The working groups, as shown in Figure 2 consist of the Crew Training Committee (CTC), the Crew Activities Working Group (CAWG) and the Payload Operations Working Group (POWG). The CTC is an in-program group consisting of writers and instructors, which regularly integrates training and simulation development activities. The CAWG is an LMSC wide group which interfaces the Program Training Manager with course writers, editors, artists, and security personnel. This group meets to coordinate the production, evaluate and distribute course materials.

The POWG is an interface group in which the developers and all of the users have opportunity to review objectives and status of the payload training program throughout their stages of development. The employment of planned interfaces by all personnel involved significantly reduces the amount of time lost in pursuing invalid requirements.

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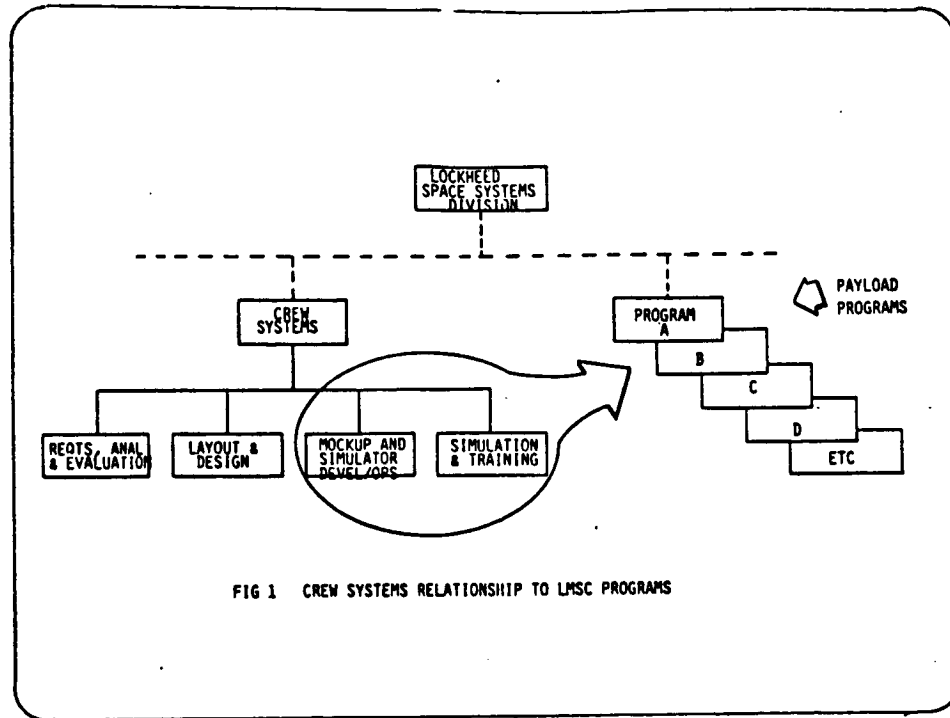


FIG 2 WORKING GROUPS ESTABLISH VITAL INTERFACES

CREW TRAINING COMMITTEE (CTC)	CREW ACTIVITIES WORKING GROUP (CAMG)	PAYLOAD OPERATIONS WORKING GROUP (PONG)
JPO (Status review)	JPO (Status review)	JPO (Status review)
P/L TRNG MANAGER	P/L TRNG MANAGER	NASA
COURSE WRITERS	COURSE WRITERS	EXPERIMENTERS
INSTRUCTORS	INSTRUCTOR	P/L TRNG MANAGER
	EDITOR	
	ARTIST	
	PUBLISHER	
	SECURITY	

Meeting Varied Needs

Several actions are taken to make training programs meet the needs of all the personnel involved, while keeping costs to a minimum. The tasks of all payload operations personnel are analyzed; a program which meets the most stringent needs (those of the Payload Specialist) is developed, and a simple tailoring strategy (for other personnel's training) is devised and implemented.

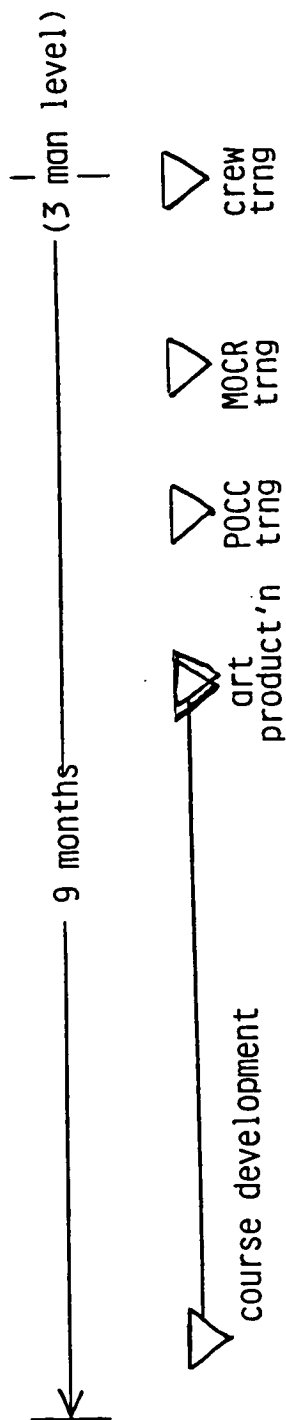
The multi-level task analysis of all ground or flight positions is essential. It provides scope for the training developers. The data for most of the analyses are found in the program proposal, the training plan and PIP annexes.

The analysis can be multi-level, in contrast to ISD methodology which insists upon rigorous task analysis for all tasks. Tasks which are understood and for which training is straight-forward receives no more than a simple inventory. On the contrary, critical tasks which are new, such as for example, IVA-EVA coordination of a manual-override operation, undergo task-timelining in detail.

Training is developed using a moderately complicated Payload Specialist scenario, which exercises all payload interfaces in the aft flight deck. The development assures that the Payload Specialist understands his mission, all of his interfaces, his equipment and the payload dedicated hardware. He experiences three stages of training: information, part-task (hands-on), and rehearsals.

Training for other personnel is usually based extensively on the Payload Specialists program. The cost effectiveness concern emphasizes the need for very minimal changing of the core training program. In a recent payload training program, hands-on training was deleted from the ground crew courses and instructors modified their

FIG 3 COURSE DEVELOPMENT (EXAMPLE)



- Overview
- P/L-Experiment Description
- Mission Planning and Timelines
- Aft Flight Panel--P/L Interface
- Payload Flight Data File
- Crew Equipment
- Course Review, Q&A

presentations to provide details or overviews, based on what the different groups required. Figure 3 summarizes the recent payload course development approach.

As a final step in keeping costs down, Lockheed has innovatively developed an approach to reduce dedicated, hard training materials. That is, no texts, no films, videotapes nor workbooks are developed specifically for payload training. The only dedicated training products for the most recently developed course were a training plan and viewfoils. The comprehensive training plan contains the course and lesson objectives providing consistent direction for the course development. The training viewfoils were used to guide the instructors and were used as handouts.

Maintaining Security

Security is a crucial concern for payload training developers. Security, which is required for program training personnel, documentation, facilities and communications interfaces increases the cost of payload training programs.

Lockheed classified programs use, in addition to internal personnel, personnel from the editing staff who maintain program clearances. This editing staff interfaces with the course production support functions such as artists, publishers, and photographers. These editors are the primary interface between the draft course materials input by the course writers and secure production support facilities. They, as well as the program course developers (writers) are familiar with the security constraints on the materials developed. LMSC has learned that it is essential to use checklists to insure that security provisions are included on the materials, that is that they are appropriately stamped, given document numbers and are controlled. Also, forms are used to pass course materials on its support functions for completion and to return

them to the course writers. Close tracking of security details is essential to prevent a time loss due to misplaced pages or improperly marked course materials.

Secure facilities are provided at LMSC for classroom training and for hands-on operation. Economy is achieved through the multi-purpose and multi-program use of common facilities. In a later paragraph, the Advanced Vehicle System SATLAB is described. It is one example of a secure training facility.

For future program requirements, there is a need to employ secure communications for integrated training and simulation. These resources are in existence at Lockheed but are not currently used for Space Shuttle payload training.

Accommodating Changes

Since payloads for each program tend to be significantly different from one another, the training courses themselves require unique efforts. The most effective way to control training development costs has been to use experienced personnel, who maintain source documents and lessons learned documentation and are familiar with using reconfigurable simulation capabilities. Using this approach, the need to reinvent is minimized.

Source documents for course development are maintained in data banks and readily accessible to program course development personnel. Where experienced personnel can short-cut analysis and training development time by using documentation from previous efforts, this documentation is normally used as a starting point. Source documents and lessons learned are a particularly valuable resource.

Payload systems are rather complex and tend to be somewhat unstable until the final stages of payload development. Lockheed has found that engineers who have skill in presenting briefings are readily convertible into instructors and are well informed on their subjects, due to their continuous involvement with the payload. A cost reduction is achieved by eliminating the time required to train an instructor to be totally conversant with spacecraft systems.

Reconfigurable Simulation

Lockheed uses the AVS SATLAB, mentioned earlier, as a hands-on Payload Specialist procedures trainer, Figure 4. The SATLAB, therefore, is a vital element in Payload Specialist training. The SATLAB layout is shown in Figure 5. A secure training facility, the SATLAB supports many aft flight deck requirements, including Payload Specialist training. Payload Specialist requirements involve using interactive monitoring/command panels. Use of the panel is normally moderated through training scenarios: and it is operated only as directed by the payload flight data file Orbit Operations Checklist. Since visual feedback of the payload is required, video monitors are positioned at the aft flight deck windows.

To assure a cost-effective, low risk implementation of the SATLAB, LMSC is using an incremental development approach. The increments were planned in four stages, each determined by payload program requirements and program funding.

The first stage uses actual flight Payload Specialist panels, and connects the panels to the payload through hardwire cables. Also closed circuit TV is used to show payload status visually.

ADVANCED VEHICLE SYSTEMS
SIMULATION AND TRAINING LAB

- HIGH FIDELITY
MOCK-UP
- INSTRUCTOR-
OPERATOR
STATION
- PAYLOAD
INTERFACE OR
SIMULATION
- INTERACTIVE
CONTROLS
- MISSION
VIDEO

FIGURE 4 SATLAB

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The second stage implements a computer simulation of the payload. The simulation provides Payload Specialist panel malfunction indications; a capability which is generally not available using the actual payload.

The third stage incorporates computer Image Generation of outside visual scenes incorporating a low-cost four window system. At this stage the orbiter attitude ephemeris and trajectory are modifiable.

The final stage of development involves including the RMS, if and when that becomes an associated Payload Specialist responsibility.

Figure 6 shows the development stages of the SATLAB and some of the support programs which are driving the phased development.

Conclusion

STS payload training at LMSC is still in its nascent stages. However, the continuing growth of the Space Shuttle payload manifest, the growing involvement of management-loop and Lockheed management's commitment to support payload IVA training indicate that Lockheed's training development programs will grow in parallel with the shuttle payload program.

Through the aforementioned training approach techniques, Lockheed has been able to reduce the overall 'classic' training program cost some 2 to 4 times from what was experienced previously. Thus, this realized saving can be passed on to the customer as a substantial cost reduction - so important in the overall responsibility of the contractor in support of STS payload development.

FIG 6 AFT FLIGHT DECK ENHANCEMENT STAGES

CAPABILITIES STAGE NO. TYPE P/L SUPPORT	CONTROL/ COMMAND PANELS	MISSION VIDEO	INSTRUCTOR OPERATOR STATION	SSV DYNAMIC CONTROL (AFD)	POTENTIAL PAYLOADS	EXISTING LMSC SIMUL S/W
STAGE 1 • control and monitor of normal ops	• actual panel driven by p/l in proximity	• cctv of payload in proximity	• communication • ref. time	none	• P-380	N/A
STAGE 2 • response to p/l malfunc't's • no schedule limitations • experiments with panel configurations	• generic AFD panel • generic p/l simulation	• S/W • scene generation	• S/W • simulation control • malif. insert	none	• LMSC R&D • engin'rg analysis	• SIMSCRIPT • GASP IV E
STAGE 3 • control orb attitude (no motion base) • scene gen.	• S/W	• scene generation	• Integrated IOS, AFD to STC & DSM	• AFD att- itude control	• ESS II	• SAMSON • SHUTTLE • DRAW P/L
STAGE 4 • deploy and berth • acquls'tn and tracking	• rapid re- configuration of p/l, panel • aca. and trk.	• deploy- ables • intercept spacecraft	• performance measurement	• RMS con- trol • capture • berth	• sp telesc • pgm B • pgm C • pgm D • non-LMSC payloads	• DOCK • PDPS • MULTI-BODY